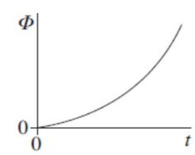
Magnetic fields	**Transformers**

Learning objectives	**MUST (C)**	Describe the structure of a transformer, and how their workings can be investigated
	SHOULD (B)	Explain how transformers work, in terms of electromagnetic induction, and how they can be made more efficient
	COULD (A/A*)	Calculate p.d, turn numbers, current and efficiency for given situations

STARTER: *Without* looking at your notes, write down the two laws that we learned last lesson.

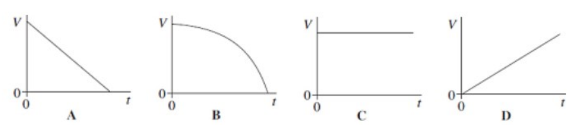
EXTENSION: Apply your knowledge to this question.

The graph shows how the magnetic flux, Φ, passing through a coil changes with time, t.



D

Which one of the following graphs could show how the magnitude of the emf, V, induced in the coil varies with t?

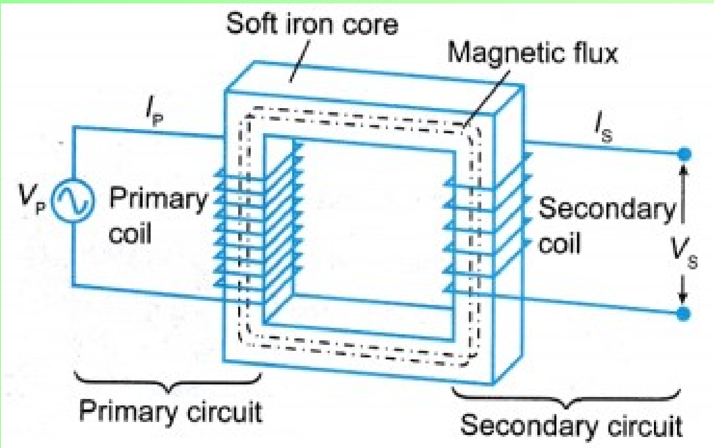


(Total 1 mark)

Faraday's Law: the magnitude of the induced emf is directly proportion to the rate of change of magnetic flux linkage

Lenz's Law: the direction of the induced emf or current is always such as to oppose the change producing it

Magnetic fields	**Transformers**
MUST (C)	Describe the structure of a transformer, and how their workings can be investigated

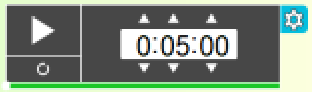


A transformer is made up of two coils on a soft iron core, with n_p turns on the primary coil and n_s turns on the secondary coil.

An **alternating current** is passed through the primary coil.

A step-up transformer: $n_s > n_p$

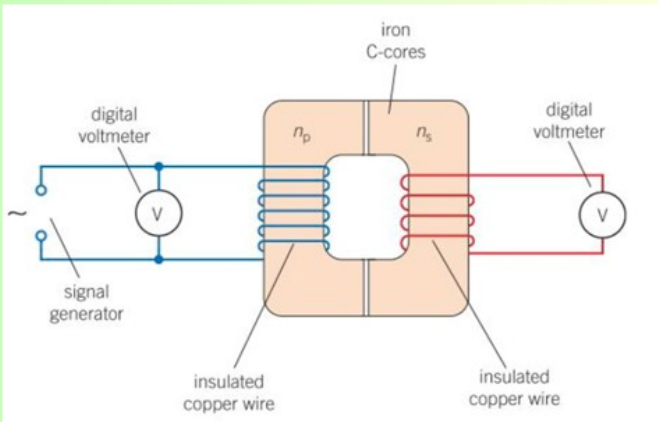
A step-down transformer: $n_p > n_s$



The workings of a transformer can be investigated experimentally with this setup: the number of turns on the primary/secondary coils can be changed, and the p.ds across the coils measured.

What would you expect to see?

Ext: How would you determine the efficiency of a transformer?

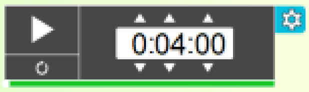


Magnetic fields	**Transformers**
SHOULD (B)	Explain how transformers work, in terms of electromagnetic induction, and how they can be made more efficient

The alternating current supplied to the primary coil produces a varying magnetic flux in the soft iron core.

Because it is wound around the same core, the secondary coil experiences this varying magnetic flux and therefore, according to Faraday's Law, an emf is induced across its ends.

The purpose of the iron core is to ensure that all of the magnetic flux links the primary and secondary coils.

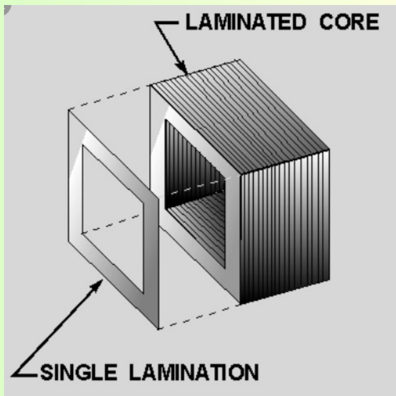


Maximising efficiency

Low-resistance windings, to reduce heating effect from current

Laminated core (layers of iron separated by insulator, rather than one solid block of iron) minimises eddy currents in the core, therefore prevents heating

Soft iron is easy to magnetise and demagnetise



Magnetic fields	**Transformers**
COULD (A/A*)	Calculate p.d, turn numbers, current and efficiency for given situations

Tasks

1. Look at 'The National Grid' in section 23.6. Make brief notes to explain why electricity must be transmitted at high voltages.

2. Use the equations below for summary questions 4-6 in section 23.6.

3. Try the PPQ, which tests knowledge of transformers and other laws of electromagnetic induction.

0:05:00

$$\text{Efficiency of a transformer} = \frac{\text{Output power}}{\text{Input power}} \times 100\%$$

$$\text{primary potential difference, } V_p \times \text{primary current, } I_p = \text{secondary potential difference, } V_s \times \text{secondary current, } I_s$$

$$\frac{\text{potential difference across primary coil, } V_p}{\text{potential difference across secondary coil, } V_s} = \frac{\text{number of turns on primary coil, } n_p}{\text{number of turns on secondary coil, } n_s}$$

$$\frac{V_p}{V_s} = \frac{n_p}{n_s}$$

4 $\dfrac{n_s}{n_p} = \dfrac{V_s}{V_p}$

$\dfrac{n_s}{500} = \dfrac{5.2}{230}$ [1]

$n_s = 11.3 \approx 11$ turns [1]

5 $\dfrac{n_s}{n_p} = \dfrac{V_s}{V_p}$

$20^{-1} = \dfrac{V_s}{230}$ [1]

$V_s = 11.5\,\text{V} \approx 12\,\text{V}$ [1]

6 a $\dfrac{n_s}{n_p} = \dfrac{V_s}{V_p}$

$\dfrac{n_s}{1000} = \dfrac{12}{230}$ [1]

$n_s = 52$ turns [1]

b For a 100% efficient transfer, the input and output powers are the same. [1]

$I_p = \dfrac{P}{V} = \dfrac{60}{230} = 0.26\,\text{A}$ [1]

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Oct 16-21:59

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A transformer has an efficiency of 80%
It has 7000 turns on its primary coil and 175 turns on its secondary coil. When the primary of the transformer is connected to a 240 V ac supply, the secondary current is 8.0 A

What are the primary current and secondary voltage?

	Primary current / mA	**Secondary voltage / V**
A	250	6.0
B	160	6.0
C	250	9600
D	160	9600

A